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BIASES IN PARAMETERIZED AUTOCONVERSION AND ACCRETION RATES DUE TO SUBGRID VARIATIONS AND CORRELATIONS OF CLOUD WATER, DROPLET NUMBER, AND DRIZZLE WATER

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ABSTRACT

Small scale processes are not explicitly represented in global climate models due to the large size of their grid-cells. Among these processes are autoconversion and accretion, both of which are important to the formation of precipitation, and are considered to have significant climatological effects. The autoconversion process represents the conversion of cloud water to drizzle water; its rate is often parameterized as a function of local cloud water content and droplet number concentration. The rate of accretion of cloud water by drizzle is often expressed as a function of local cloud water content and drizzle water content. It is well known that the distributions of cloud water, droplet number, and drizzle water are spatially inhomogeneous. This could lead to biases in grid-mean autoconversion and accretion rates if the subgrid variations are not accounted for. The impact of subgrid variation of cloud water on autoconversion parameterization was examined in earlier studies and is taken into consideration by cloud microphysics schemes in some global models.

In this study, the effects of subgrid variations of cloud water, droplet number, and drizzle water, and the correlations among them on parameterized mean autoconversion and accretion rates are examined using in-situ measurements during Marine Stratus/stratocumulus Experiment (MASE) and VAMOS Ocean-Cloud-Atmosphere-Land Study - Regional Experiment (VOCALS-REx). The results suggest that the bias in autoconversion rate is mainly due to subgrid variation of cloud water, and the contributions due to the variation of droplet number and the correlation between droplet number and cloud water are often minor. The bias can be calculated within ~20% using the relative standard deviation (RSD) of cloud water content alone. The bias in mean accretion rate can exceed a factor of 2 if subgrid variations are neglected. This bias in accretion rate is mainly due to the positive correlation between cloud water and drizzle water (i.e., high drizzle water content is often associated with high cloud water content). At high accretion rates, this bias can also be parameterized using RSD of cloud water content. This study demonstrates the knowledge of RSD of cloud water content is required to accurately calculate grid mean autoconversion and accretion rates. The RSD of cloud water content measured during the two field studies is presented as a function of spatial scale and discussed.